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YAMAHA

Yamaha Guitars

Essential Knowledge

Yamaha Strengths, Artist's Advantage

"Yamaha Guitars: Essential Knowledge" has been created to give you a behind-the-scenes view of the surprisingly vast and varied resources, facilities, skills, and people involved in making Yamaha guitars the special instruments that they are. Yamaha's enviable position in musical instrument manufacturing is not only a result of more than 120 years of experience (the company was established in 1887), but also of the unique strengths that its expansive operations bring to bear. From research and development through design and manufacturing to sales and support, Yamaha goes to lengths that are simply beyond the capabilities of most guitar makers. But an underlying dedication to music and the creation of fine musical instruments is always there, forming a steadfast foundation that often results in profit taking a back seat to the pursuit of quality.

Yamaha's true strengths as a guitar maker are not apparent in product brochures or specifications, but they are clearly reflected in the sound, playability, dependability, and overall quality of every guitar that bears the Yamaha name. "Essential Knowledge" includes information that will hopefully provide a clearer picture of the prodigious resources and effort that give artists who choose Yamaha a significant musical advantage.

Contents

Research & Material Optimization....p.4
Woods....p.6
The Acoustic Guitar
Elements of Sound and Playability....p.8
The Electric Guitar
Elements of Sound and Playability....p.11
Electronics
Acoustic Amplification with Optimum Tone....p.13
Electric Guitar Pickups and Electronics....p.15
Craftsmanship....p.17
Quality Control from Concept to Service....p.20
Worldwide Standards....p.23
From the Player's Perspective....p.24
Classical Tradition....p.25
People....p.26
History....p.30

A partial view of Yamaha's extensive Tenryu facility where the wood research center is located.

Research & Material Optimization

At Yamaha, the process of making great guitars begins long before the raw materials are even delivered to the factory. Of course selection and procurement of woods and other materials are critical steps, but the Yamaha difference goes even further. The resources and facilities that Yamaha applies to basic research and development alone are more extensive than many guitar makers apply to actual production. And that level of involvement stretches back for decades, giving the company an extraordinary stockpile of experience and know-how that makes it possible to deliver innovative features and refinements that are truly meaningful in a musical context.

Traditional craftsmanship is still the mainstay of fine guitar manufacture, but innovative research and material optimization drives the craft forward, providing unprecedented tonality and playability that enables musicians to take their own craft to new heights.

There's Wood, and there's Yamaha Wood

There are very good reasons why guitars continue to be made using wood rather than high-tech man-made materials. To put it as directly as possible: there is simply nothing better. But ensuring that the woods used deliver optimum performance in the form of musical instruments requires special handling and crafting techniques that in many cases resist scientific definition. It is an art that verges on mysticism in many ways, but at the same time it is essential for a manufacturer like Yamaha to understand how the materials respond and perform in order to deliver consistently high quality in every instrument that goes out the factory door.

And here's where the Yamaha difference starts to show. Yamaha's involvement with wood goes beyond mere "understanding" and enters the realm of "control and optimization." An extensive and vigorous R&D program not only provides the data needed to make the most of the woods available, but also makes it possible to modify and control their characteristics in ways that make them even more suitable for use in musical instruments.

A corner of the research center "wood library." Samples of woods from all over the world are kept for reference and study.

A section of Yamaha's research woodshop. This would be a full production facility for some manufacturers.

A.R.E. – Acoustic Resonance Enhancement

There is no question that the sonic properties of wood change, often improving, as the wood ages. Although time is the only factor that can truly age anything, Yamaha embarked on an in-depth research program to try and understand what changes were actually occurring in the wood, and how that information might be applied to improve the characteristics of younger woods. After years of development the Acoustic Resonance Enhancement (A.R.E.) process was born, and is gradually being implemented in more instruments as its benefits are being proven.

To clarify, A.R.E. is not specifically an aging process. The changes it brings about in the wood are similar to those observed in aged wood, but the focus is resolutely on achieving superior sound rather an "aged" sound. A.R.E. has proven to be extraordinarily successful in optimizing the sonic qualities of wood destined for use in Yamaha guitars.

This unique process causes physical changes at the cellular level, most directly affecting the wood's cellulose and hemicellulose. Sound transmission is significantly enhanced: the wood becomes more responsive to input from the strings, and transmits the vibration of the strings with greater accuracy. In sonic terms, the harsh "edge" that is often heard in young wood is reduced, while the sustain characteristics at different frequencies are brought into a more balanced, well-coordinated relationship. The only way to really understand the effect is to hear it, but expect to experience a crisp attack with a clean high end that is smoothly coupled to harmonically rich mids and lows with remarkable sustain. The sum result is outstanding balance with ideal response and sustain throughout the instrument's frequency range.

A side benefit of A.R.E. processing is that it helps to stabilize the wood in addition to improving its sonic properties. Wood is very active in absorbing moisture from damp atmospheres and then releasing it again when moved to a dry location. For example, if proper care is not taken a guitar produced in a very humid location that is then shipped to a dry environment can be prone to shrinkage and cracking or distortion. Although Yamaha employs multiple technologies as well as severe testing to ensure the stability of its guitars, A.R.E. further contributes to stability by minimizing changes in the wood as it is moved between different atmospheric conditions.

One of Yamaha's A.R.E. processing chambers.

Drying Technology

Yamaha expertise in drying woods for musical instruments is unparalleled. That knowledge comes from decades of experience in preparing woods for pianos, drums, bowed string instruments, woodwind instruments, marimbas, and more. There are some who argue that natural drying is the only way to go, but under properly controlled conditions – and "control" is the key – artificial drying is capable of achieving more consistent stability and quality.

Even after more than 50 years of leadership in the field, Yamaha continues to research and document drying methods, applying refinements as they become available to ensure consistently superior stability and performance in every instrument produced.

Finishes and Adhesives

FFT analysis is used to acquire data on the sonic properties of various finishes.

Most of the finishes used on Yamaha guitars are formulated in-house. Off-the-shelf products simply will not do because, in addition to looking good and providing durable protection under a wide range of conditions, guitar finishes have to complement the instrument's sound as well. The Yamaha research center employs advanced techniques to test and measure the sonic characteristics of finishes as applied to guitar tone woods. The finish must allow the most desirable sonic properties of the wood to come through without damping resonance or sustain, while at the same time providing protection and lasting beauty.

But even the most perfectly formulated finish won't deliver the desired results unless it is applied properly, and this is another important area for research. The quality of finishes is affected during application by many factors: temperature, humidity, spray flow, number of applications, thickness, drying, and more. The research center performs exhaustive testing under a variety of conditions to determine the optimum application conditions for each type of finish, and that know-how is then taken to the factories where it is applied to actual production.

The same type of testing is carried out for adhesives as well: how many grams of adhesive must be used for how many square meters of surface area, with parts brought together within how much time at what temperature, and then subjected to how many kilograms of pressure for how long … it's complicated, but all of these parameters have a significant influence on the quality of the glued joint. The research center finds the optimum values and passes that information on to the production divisions.

This area of the research center is devoted to testing the characteristics of wood adhesives.

Experience Makes the Data Meaningful

Since initial testing on individual components such as woods, finishes, or adhesives only reveals the characteristics of the materials themselves, a great deal of experience is required to be able to predict how those components will affect the overall performance of an instrument. This is one of the areas where Yamaha's many years of experience and accumulated know-how are extremely valuable.

Research performed without a strong background of experience is essentially being performed in the dark. Yamaha's extensive history is the critical "secret ingredient" that throws light on the results, enabling engineers and craftsmen to apply them in meaningful ways.

Woods

The individual woods used in a guitar and the way they are combined are the instrument's most fundamental tone shaping elements. There is no "best" wood or combination: the individual player's tonal preferences and performing needs are the ultimate deciding factors. But there are basic requirements for strength, stability, and tonal balance that guide the selection. And of course once a type of wood has been decided on, it then becomes necessary to select the best specimens and take the best cuts from the stock that is available. Cutting the wood is an art in itself, and getting the best cuts from raw stock for guitar use requires a keen eye and years of experience.

The chart below lists some of the woods used for various parts of Yamaha guitars along with their source and main characteristics.

Top

Species	Source	
Sitka Spruce	Canada. Alaska.	Rich mid and low range. Improves with playing and age. Slightly harder than other Spruces.
Engleman Spruce	British Columbia, Canada.	Rich mid and low range. Improves with playing and age. Softer than other spruces.
Ezo (Yezo) Spruce	Hokkaido, Japan.	Rich mid and low range. Improves with playing and age. Depleted resources – difficult to obtain.
German Spruce	European Alps	Rich mid and low range. Improves with playing and age. Used for the finest classical guitars.
Western Red Cedar	North America	Distinctive high end. Doesn't age as well as spruce.

Back, Sides, and Neck

Species	Source	
Honduras Mahogany	South America, Honduras.	The finest mahogany. Used for handmade guitar necks.
African Mahogany	Africa.	Not quite as strong as Honduras Mahogany.
Ovangkol	Southeast Asia. West Africa.	An alternative to rosewood.
Nato	Indonesia.	An alternative to Mahogany.
Padauk	Central & West Africa.	An alternative to rosewood. Strong tone.

Back and Sides, Fingerboard

Species	Source	
Jacaranda (Brazilian Rosewood)	Brazil.	Solid lows and brilliant highs. This species is protected and cannot be traded.
Palisander (Indian Rosewood)	India. Africa.	Softer tone than Jacaranda.
Honduras Rosewood	Honduras	Heavier than Jacaranda, with a correspondingly heavier sound.
Maple	America. Canada.	Sweet, thick tone. Flame maple is commonly used in guitars (top sample). Other types include quilted maple (lower sample) and bird's-eye maple.

Fingerboard and Bridge

Species	Source	
Ebony	Africa & Southeast Asia	Extremely hard and durable. Used in handmade guitars.

Solid Guitar Bodies

Species	Source	
Ash	U.S.A.	Very light with outstanding tonal qualities: clear ringing highs and deep warm lows.
Alder	South America	Light weight with well-balanced tone.
Agathis	Asia, South Pacific	Similar to mahogany in tone. Excellent stability.

Tone woods for guitars at one of Yamaha's temperature and humidity controlled storage facilities.

Drying and Seasoning

In Yamaha terminology, drying and seasoning are related but distinct processes that have different goals. Drying is initially employed to reduce the moisture content of the wood to a predetermined level, and seasoning then stabilizes the wood so that it maintains its dimensional and tonal characteristics through varying ambient conditions. Some manufacturers simply buy pre-dried wood from an outside supplier. Yamaha has a long history of wood processing expertise, and is very serious about ensuring that all woods used in Yamaha guitars are dried and seasoned to exacting standards.

A wood drying kiln at Yamaha's Music Craft workshop in Hamamatsu, Japan.

Endangered Species and the Environment

Unfortunately unsustainable harvesting of some of the exotic woods used in guitars has endangered their continued existence, and they must be protected. This means that they cannot be harvested or traded, so fresh supplies are simply unavailable until alternative sources are secured. Existing stocks will continue to be used until they run out.

Although the acoustic properties of many of these woods are ideal for musical instrument use, the health of our planet is far more important. As outlined in the preceding section, Yamaha maintains an active materials research and development program that is working to optimize the characteristics of alternative woods as well as develop new materials that will have minimal impact on the environment.

Living trees absorb carbon dioxide from the air and produce vital oxygen as they grow. They are an essential part of the natural mechanism that maintains balance and sustains life on our planet. Yamaha has been making musical instruments for 120 years, but that legacy can only continue into the future if we promote the sustainable use of wood resources and sensitivity to issues of biodiversity and the depletion of natural resources. Toward this end, Yamaha has established the following "Yamaha Timber Procurement and Usage Guidelines."

Yamaha Timber Procurement and Usage Guidelines

Fundamental Philosophy

Yamaha is working on measures aimed at preserving the global environment, and plans to enact the following guidelines for the procurement and use of timber in products that allow us to contribute to a more harmonious relationship between society and nature.

Procurement and Usage Guidelines

- **Procuring appropriate timber.**
  Promote procurement of timber that is environmentally friendly from harvest to product delivery, and that can be confirmed as having been appropriately managed.
- **Prioritize procurement of afforested timber from planted forests.**
  Put priority on procuring timber harvested from planted forests.
- **Active use of manufactured wood materials.**
  Promote use of plywood and wood fiberboard as these contain a high percentage of afforested timber and recycled timber.
- **Increase the efficiency with which we use timber, raising our yield ratio.**
  Actively promote the use of timber remnants and improve yield ratios through improved processing methods and technological development.

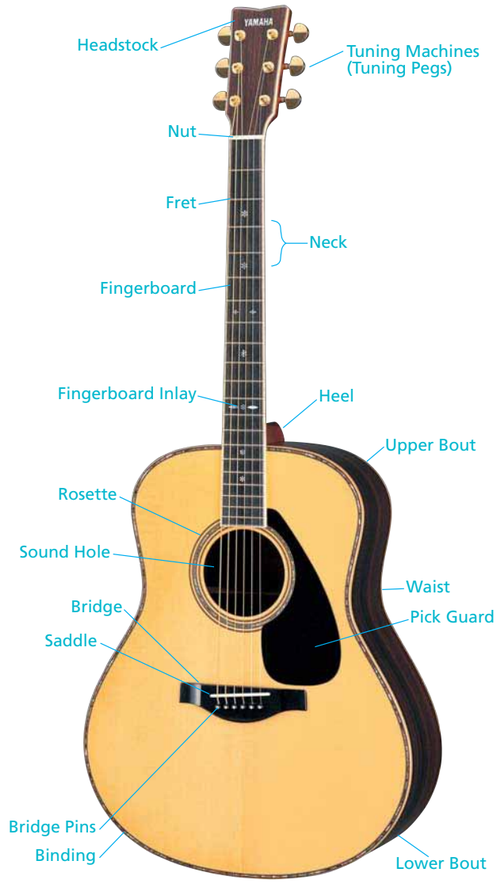
The Acoustic Guitar

Elements of Sound and Playability

The acoustic guitar's body is its main amplification and resonance structure, and it makes the largest contribution to the instrument's overall sound. But although it is the largest tone determining element, it is by no means the only one. The body's contribution is influenced by every other part of the instrument: from the relatively large neck right down to the glue that holds the bridge to the guitar's top. The guitar is an extremely complex sound producing mechanism, and everything in contact with it – including the player's body and fingers – makes a difference.

That's why producing a great guitar is such a difficult task. The number of factors affecting a guitar's tone is nothing less than overwhelming, and bringing them all together in an instrument that provides the desired sound and playability, not to mention durability and beauty, is a significant achievement that hinges as much on the experience and sensitivity of the builder as on fundamental physical principles.

In this section we'll take a brief look at some of the main elements that influence an acoustic guitar's sound and playability. But keep in mind that none of these elements produce the desired result in isolation. Each depends on every other in a finely balanced and tuned music making system.



Body

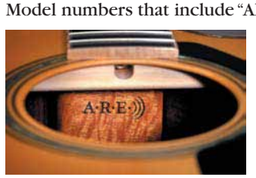
Vibration of the guitar's strings is transmitted to the top of the body via the bridge. The top, driven by the strings, becomes the instrument's primary "diaphragm," producing most of its audible output. The top is supported by the back and sides, which make their own contributions to the guitar's tone and projection characteristics.

Here are just a few of the elements that add up to define how a guitar body will sound.

Woods

One of several varieties of spruce is used for the top of most Yamaha acoustic guitars. Select Engleman Spruce is an important feature of the LL, LS, and LJ series instruments. Back and sides might be a rosewood variety, mahogany, nato, or ovangkol. But the fact that a particular type of wood is more exotic and expensive doesn't necessarily mean that it's "better." Only the player can decide what combination of woods and guitar design is best for his or her music.

Model numbers that include "ARE" indicate models with tops that have been processed using Yamaha's groundbreaking A.R.E. technology – discussed in more detail in the "Research and Material Optimization" section – for exceptionally smooth, musical tone and response.



Shape & Dimensions

Acoustic guitar bodies are curvaceous creations for a very good reason: their shape allows them to resonate effectively over a broad range of frequencies, giving them the qualities of a musical instrument rather than just a box with a hole in it. Variations in body size and shape affect the balance of the tone produced as well as the instrument's volume.

Large bodies with a broad waist generally produce greater volume with a smooth midrange and more emphasis on the lower frequencies. Bodies with a smaller waist usually deliver a tighter, more focused tone. The choice is entirely personal, and will depend on the type of music played, how it is played (strummed or finger picked, for example), and the environment it is played in (solo, with other guitars, in ensemble with other types of instruments, etc.).

Another body shape consideration for players who frequently use the highest fret positions is the cutaway. This feature is provided on some Yamaha acoustic guitar models, allowing freer access and far greater mobility at the upper frets than is available on traditional non cutaway bodies.

CPX model with cutaway for easy high-fret access.

Bookmatching

Solid acoustic guitar tops are not a single piece of wood, but rather two pieces joined down the center of the top. These two pieces of wood are "bookmatched," meaning that they are cut from the same plank, sliced into two thinner planks and opened up like a book. The resultant grain pattern will therefore be symmetrical with respect to the central seam. The very best guitar tops are cut so that the grain becomes wider toward the outside of the top. In all cases the selection, cutting, and bookmatching of woods for guitar tops are critical processes that demand a great deal of skill and experience.

Bracing

Bracing – thin strips of wood glued to the underside of the guitar's top – is, in addition to the type and cut of the wood used, one of the most important elements influencing the guitar's volume and tone. Bracing applied to the back and sides also has an effect on sonic performance. The bracing configuration used can mean the difference between the success or failure of an instrument, and ideally will complement and enhance the qualities of the woods used and the instrument's overall design. Too much bracing or braces that are too heavy will result in a dead sounding guitar. At the other extreme – too little bracing or braces that are too light – the guitar might sound unfocused and boomy, and the top may be prone to distortion and breakage.

Guitar top bracing patterns can be broadly categorized into two types: "X bracing" and "fan bracing," each of which has essentially limitless variations. X bracing is generally the best match for the higher string tension of steel string guitars, while fan bracing is better suited to bringing out the tonal subtleties of nylon string guitars with their lower tension.

An example of X bracing for a steel string guitar. Note the tapered braces.

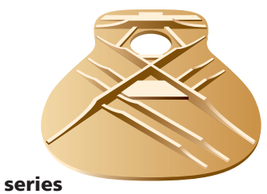
In addition to the placement of the braces and their dimensions, the taper of the braces is a critical feature that is crafted by hand in high end models. A straight taper is used on some types of bracing, while a curved taper is used on others. The taper determines how the top flexes across its surface, defining its response and how vibrations from the strings are transmitted throughout the top. For the finest hand made guitars the craftsman will carefully shave the braces to their approximate final shape, tap the top to hear how it sounds, and then make adjustments and repeat until the response is perfect.

In some cases the braces will be "scalloped" – a curved depression will be carved near the center of the brace – to increase the flexibility of the top and increase bass response. But, like most other guitar features, this one has to be matched the instrument's materials and design for optimum effect. Yamaha APX series guitars, for example, use scalloped bracing in order to deliver well balanced bass from their relatively compact, shallow bodies. In most larger bodies nonscalloped straight bracing delivers the optimum tonal balance.

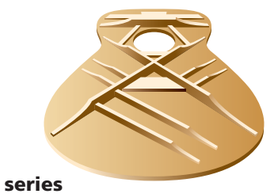
Every Yamaha acoustic guitar model has it's own bracing pattern that is designed to optimize the performance of that particular model. Some of the major variations are illustrated below.

Yamaha Bracing Patterns

LL/LS/LJ series
Excellent balance between response and sound. Thick tone with rich bass.



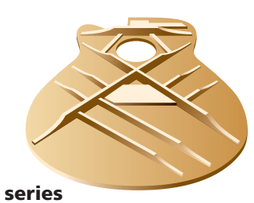
FG series
This is the basic configuration behind Yamaha's original FG sound. Deep and strong with crisp attack



FS series
This pattern achieves optimum playability with the 634-mm scale and compact bodies of the FS series. Well-balanced sound.

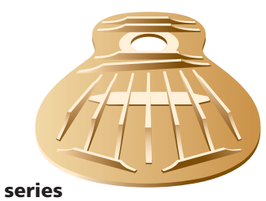
NX Series, NCX/NTX Models
Designed to bring out the best in nylon string tone while accommodating a wide range of playing styles.

NX Series, NCX2000 Model
This design faithfully reproduces the finest performance details with a clear, bright high range and deep, rich lows.

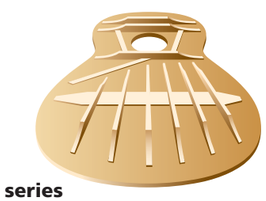


CPX series
Minimum feedback even when playing big, powerful chords. Great response and dynamics.

APX series
Outstanding projection and clarity in the upper registers that is ideal for electro-acoustic lead work.



GC series
Bright, well defined highs plus deep, resonant lows. This pattern brings out the best in the GC series top materials.



CG series
Precise pitch coupled with superb balance and excellent durability. Used in high-quality standard models.

Top and Back Curvature

This feature is not often given much attention, but it is important both for strength and sound. Giving the top a slight outward curve adds strength and allows the use of a thinner top and lighter bracing while optimizing transmission from the strings. The balance between the top's curvature, thickness, and bracing is significant in determining tone. Back curvature also enhances strength while helping to define the overall response and resonance of the body.

Bridge

This critical component transfers the vibrations of the guitar's strings to the body where they are amplified and invested with the instrument's characteristic tone. The bridge also plays a vital role in determining the guitar's pitch accuracy and intonation, and must be installed with the utmost precision.

The bridge of an acoustic guitar usually consists of two main components: the bridge base and the saddle (sometimes multiple saddles). The saddle rests in a groove in the bridge base, which is glued directly to the top of the guitar. Since string vibrations must be transmitted accurately to the body with minimum damping, relatively hard materials are used for both bridge base and saddle. The bridge base is generally made of a dense hardwood such as ebony or rosewood, while the saddle will be made of bone (ivory is no longer an option) or a hard plastic. The materials used for the bridge have a considerable effect on the guitar's tone.

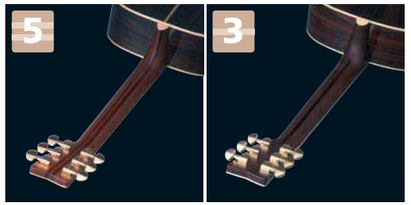
The strings rest on the saddle, in grooves precisely cut to receive them while maintaining proper string spacing and radius. To maintain proper intonation for all six strings the saddle is installed at a precisely calculated angle, with the high E string end a bit closer to the neck than the low E string end. The third (G) string sometimes requires a slight offset in the saddle to achieve proper intonation.

Neck

The guitar neck is often seen solely from the perspective of playability, but there is much more to it than that. Although the neck is where much of the playing action happens, it also has a substantial influence on the instrument's tone and sustain.

Woods and Construction

Since one of the most important characteristics of a guitar neck is rigidity, usually the hardest, densest woods are used: mahogany, rosewood, nato, padauk, and sometimes maple. Necks can be carved from a single piece of hardwood, or laminated in three or five pieces for added strength and rigidity. Yamaha laminates mahogany with rosewood, padauk, or ebony in three piece and five piece necks.



Yamaha five piece (left) and three piece (right) necks.

Truss Rod

The tension produced by a tuned up set of steel strings is considerable, and is enough to warp even the stiffest wood neck. To counteract this force, steel string guitars have a metal "truss rod" embedded in the neck with a hex nut or allen key nut on one end that can be adjusted to precisely compensate for the tension of the strings. The adjustment nut can usually be accessed either via a removable cover on the headstock, or at the body end of the neck through the sound hole. Nylon string guitars often don't have or need a truss rod because the tension of nylon strings is much lower than steel.

Careful adjustment of the truss rod not only counteracts the string tension, but also allows the neck to be fine tuned for maximum playability. Allowing a small amount of neck "relief" (curvature towards the fingerboard) makes it possible to lower the guitar's "action" (the height of the strings from the fingerboard) more than is possible if the neck is perfectly straight, for example.

Neck-body Joint

Yamaha acoustic guitars use "set" necks, which means that the neck is fitted and glued into a recess in the end of the body. The recess is actually cut into a specially shaped block that is installed inside the body. The way this is done is critical to achieving optimum tone as well as durability, and Yamaha has an original approach. Rather than

Bodies numbered so they can be reunited with perfectly matched necks after finishing.

the more conventional mortise and tenon or dovetail joint, Yamaha employs an innovative, complex joint configuration that ensures consistently intimate contact between the neck and body. This is important because the transmission of vibration between the neck and body plays a major role in shaping response and sustain.

The fit of the neck is so important to Yamaha that the neck and body are perfectly matched and numbered before the finish is applied. The neck and body are then finished separately, and once that process is complete the matched pair is brought back together for final assembly. This painstaking approach ensures that every guitar that leaves the factory has a perfectly matched neck and body.

Shape

Although primarily a playability issue, the shape of a neck also affects its overall mass, which does have an effect on tone. The profile of the neck can range from a somewhat flattened "D" through a rounded "D" to a distinct "V" shape. The choice is strictly personal, but Yamaha has spent many years researching and refining the ideal neck shape for most players.

Fingerboard & Frets

The fingerboard and frets are the main interface between the player's fretting hand and the instrument, so precision is essential. Ebony and rosewood are the most commonly used fingerboard woods, providing the ideal blend of durability and resilience for optimum tone. Fret grooves are cut into the fingerboard blanks using precision computer controlled cutters to ensure consistently accurate pitch at all positions. The material, height, width, and overall shape of the frets themselves also affect playability, tone, and intonation, so frets are manufactured and installed with the utmost care.

Nut

The guitar's strings are suspended between the bridge on the body and the nut, and it is the distance between the bridge and nut that determines the pitch of the open string. The need for precision is obvious. The nut has grooves in which the strings rest that are carefully cut to the appropriate size, shape and depth. A poorly cut nut can cause intonation problems and string buzz.

Elements of Sound and Playability

The Electric Guitar

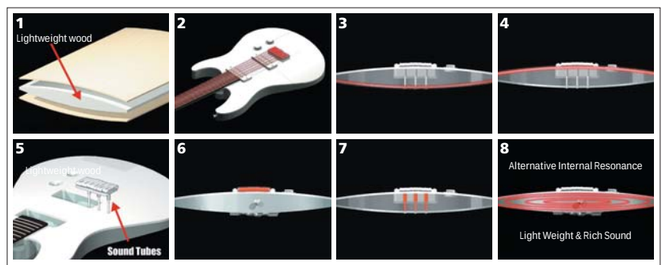
Electric guitars and basses are just as dependent on woods and construction for great tone as acoustic guitars, but in a slightly different way. Whereas the sound of acoustic guitars is almost entirely created by the woods and materials used and how the instrument is constructed, electric instruments include an added component that affects tone in a big way: the pickup(s). We'll look at pickups in more detail in a later chapter, but there's no way to discuss electric guitar body/neck construction without pointing out that the matching between body and pickups is critical in achieving the desired sound. In some ways that makes it even more difficult to build a great electric guitar or bass than it is to create a first-class acoustic guitar. Electric guitars and basses are most definitely not, as some like to say, merely planks with pickups. The woods used and the way they are constructed are critical to achieving optimum harmony and balance with the pickups used.

Body Shape

The issue of how much the body shape of a solid-body electric guitar affects its tone tends to be controversial, but anyone who has spent time building, modifying, or repairing such instruments knows the truth: the effect is significant. At the same time, it's impossible to assign specific sonic characteristics to specific shapes simply because every aspect of the instrument interacts – body, neck, headstock, machine heads, nut, bridge, tailpiece, pickups, wiring, strings, etc. – so that a given shape might result in different tonalities when matched with different components in other areas. Nonetheless, if you change the shape you'll change the tone, and that includes the body routing as well. Changing the shape of the recesses that house the pickups, controls, and wiring can affect the tone, even though such changes may not be visually apparent. This is the main reason that the classic SG solid-body form, for example, remains unchanged. The SG design is remarkably well balanced from a sonic perspective, and although countless variations have been tried, none have delivered the smooth, uniform response of the original design. Even the distinctive cutaway "horns" are critical to the SG sound. Similarly, BB-series electric bass guitars all have the same basic body form for the same reason: optimum tone.

Body Composition

Like acoustic guitars, the wood or combinations of woods used in an electric guitar's body is a fundamental underlying factor in determining the instrument's tone. Also like acoustic guitars, there are no hard-and-fast rules. While traditional materials such as alder, maple, and mahogany are used for many Yamaha electric guitars and basses, innovative compositions like the A.I.R (Alternative Internal Resonance) body of the RGXA2 and RBXA2 can deliver groundbreaking playability and sound as well. It's how the materials are used that really matters, and that is both an art and a science that requires a combination of technological expertise, tireless trial-and-error testing, and an understanding of what artists really want and need to create great music.



A. I. R. (Alternative Internal Resonance) Design

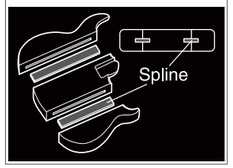
Using Yamaha's original Alternative Internal Resonance technology the RGXA2 and RBX4A2 offer players excellent lightweight characteristics without sacrificing sound quality.

- The body consists of a lightweight core sandwiched between hard woods on top and back.(1)
- Three metal tubes (sound tubes) installed under the bridge plate transmit string vibration to the body, and return body vibration to the bridge. (2)
- The top board quickly responds to string vibration passing through the bridge. Special sound tubes passing through the body produce rich resonance in the core material. The backboard resonates, exciting the entire body structure and creating a full, powerful, and resonant tone with distinctive presence and body that are truly unique. (3)-(8)

Body Joinery

There are many reasons to use multiple pieces of wood for solid guitar bodies, including the ability to use the most choice sections of wood, response balancing and visual symmetry through book-matching, the ability to combine different types of wood to control tone, and economy, among others. No matter what the reason, it is critical that the individual parts be joined with the utmost precision and intimacy so that the body can respond as a whole. The basics for achieving this are precise shaping of wood surfaces for a perfect fit, appropriate choice and application of adhesives, and the design and use of tools and jigs that ensure consistent joints from instrument to instrument. In some cases special techniques are used to ensure absolute body integrity. The BB2000/1000 series basses, for example, have three-piece bodies in which the alder center and side sections are joined using almost full-length hard-maple splines, ensuring optimum vibration transmission throughout the body for outstanding resonance and sustain.

Spline Jointed 3-Piece Body
(BB2000/1000 Series)



Neck Construction and Attachment

The basic requirements for a great electric guitar or bass neck are the same as those for acoustic guitar necks, so you can refer to the "Neck" section in the "Elements of Sound and Playability – Acoustic Guitars" chapter for details. The main difference is in how the neck is attached to the body. Set neck attachment similar to that used for Yamaha acoustic guitars is used in some Yamaha electric guitars as well, but not all. In some cases a through neck or bolt-on neck is a better choice for an electric instrument. Here's a quick rundown:

Set Neck	One of the benefits of set necks for acoustic guitars is that they can provide a strong, intimate joint without intruding into the body and degrading acoustic performance. The situation is similar for some electric guitars in which the integrity of the body as a unit needs to be maintained for optimum tone.
Through Neck	In this type of construction the neck extends right through the instrument's body. The body shape is completed by "wings" joined to the neck extension. The pickups, bridge, and tailpiece are all attached directly to the neck extension so that there is an uninterrupted transmission path from the tailpiece to the headstock.
Bolt-on Neck	In addition to convenience – and they most certainly are convenient in terms of setup, maintenance, and repair – bolt on necks actually have their own sonic signature that is desirable in some instruments. While SG electric guitars feature through necks, for example, the top-of-the-line BB series electric basses have bolt-on necks that, in that particular context, provide ideal attack and response.

A.R.E. and I.R.A.

Yamaha's original A.R.E. (Acoustic Resonance Enhancement) wood processing technology is now being used in electric instruments as well as acoustic guitars (refer to the "Research & Material Optimization" chapter for details). BB2000 series bass bodies, for example, are lovingly built from choice alder that has undergone A.R.E. processing, delivering tone that is smooth and mature.

A.R.E. processed wood ready to be transformed into electric bass bodies.

An SG-series electric guitar undergoing I.R.A. processing at the factory.

I.R.A. (Initial Response Acceleration) is another proprietary Yamaha process that is applied to guitars and basses after final assembly to ensure that all aspects of the instrument – woods, joints, finishes, and hardware – are working in harmony to deliver the best tone and response possible.

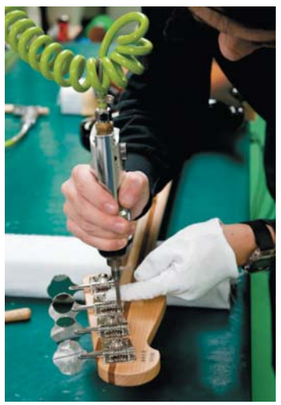
Both of these important technologies mean that a Yamaha guitar or bass will sound and play great from the first note, without needing years of "playing in," but will also continue to improve as time goes on.

Bridge and Tailpiece

Since the bridge is the primary point at which string vibration is transferred to the instrument's body, any changes in material and design will change the sound. Unlike acoustic guitar bridges, which are usually made of hard wood bonded directly to the body with bone or hard plastic saddles, electric guitar and bass bridges are most commonly made of metal alloys. The bridge and tailpiece can be separate, or both functions can be integrated into a single bridge/tailpiece unit. Electric guitar and bass bridges often feature "tunable" saddles that can be precisely positioned to achieve accurate intonation. One aspect of bridge/tailpiece design that has a surprisingly large effect on both tone and playability is the angle at which the strings meet the saddles from the tailpiece side. Some Yamaha instruments even provide a choice of stringing options, like the BB2000/1000/400 series basses that provide both "Diagonal thru Body Stringing," and stringing directly through the tail end of the bridge, whichever the player prefers.

Machine Heads

Not only are machine heads important for fast, accurate tuning and tuning stability, but they actually affect tone as well. The mass of the machine heads directly affects the resonance of the instrument's neck, thus playing a small but noticeable role in determining overall tone. The details really do count.



Electronics: Acoustic Amplification with Optimum Tone

When the size of a venue or the need to record makes amplification necessary, the main requirement is usually to make the guitar sound as close as possible to the way it does naturally, and this is easier said than done.

When we hear an acoustic guitar up close and unamplified we're hearing sound from virtually every part of the instrument: the top, back, sides, and even the neck and headstock to some extent. The sum total of all of that sound is the guitar's true, natural tone.

Now consider what happens when the sound of the guitar is to be picked up by an external microphone. In order to pick up only the sound of the guitar as efficiently as possible the microphone has to be moved in quite close, but that at the same time means that the microphone "focuses" on a small area of the instrument with the result that the tone becomes unbalanced. When using external microphones most live sound and recording engineers will, whenever possible, use two microphones on different areas of an acoustic guitar in order to achieve a balanced, musical sound.

Built in microphones, especially the "contact" type that are directly attached to a part of the guitar's body, are an even greater challenge because they generally pick up the instrument's sound only at the point of attachment. Not only do the microphones (usually called "pickups" when they are directly attached to the instrument) have to be specially designed for the application, they have to be positioned at the ideal location for optimum tonal and dynamic balance. Multiple pickups at different locations are often used to achieve a well balanced, natural sound. The preamplifier used with built in pickups will also often be "voiced" (equalized) to achieve a natural tone, and variable EQ controls may be provided to give the performer some control to adjust for personal preference as well as the widely varying acoustics of performing venues.

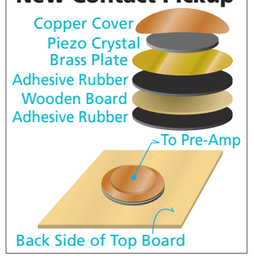
Another issue with built in pickups is that they effectively turn the entire instrument into one big microphone that can require extra care and attention in live performing situations. Output from the sound system speakers can be picked up by the guitar body, amplified again and fed back to the system, forming a loop that can cause the loud, piercing oscillation known as "feedback." Careful pickup design and placement can go a long way toward minimizing this problem, as can sound hole covers and other means of reducing the instrument's sensitivity to external sound waves.

Yamaha Acoustic Resonance Transducer Technology

Piezo transducers are ideal for contact pickup use, allowing accurate, efficient pickup of vibrations from the surface to which they are attached. It is this very accuracy that can be a problem when piezo pickups are attached directly to a guitar's top, because they reproduce attack transients and dynamics that are not efficiently transmitted via the air, resulting in a balance that would only be accurate if you were listening with your ear pressed against the guitar's top. Yamaha has effectively resolved this imbalance in the innovative A.R.T. (Acoustic Resonance Transducer), delivering smooth, natural response that corresponds closely to the natural sound of the instrument.

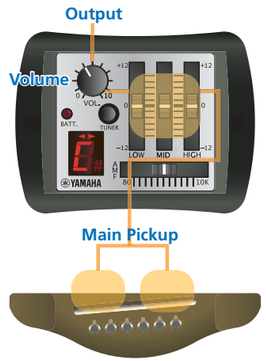
The A.R.T. pickup features a multi layer structure that provides the ideal degree of damping without losing tonal subtleties that are essential to the guitar's sound. Since it is possible to attach this advanced pickup directly to the underside of the guitar's top, more of the instrument's inherent resonance and tone can be included in the amplified sound.

New Contact Pickup



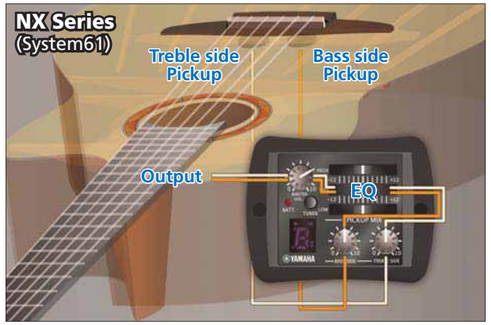
The A.R.T. pickup is available in one way and three way pickup systems, but even in the one way System 56 two pickups are employed for optimum balance.

CPX700 and APX700 models
(System56)

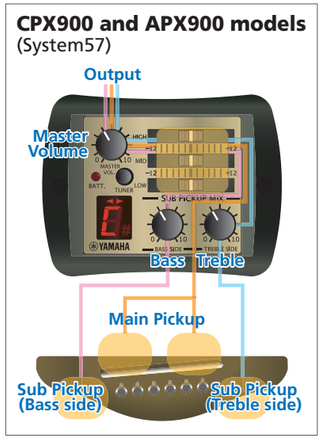


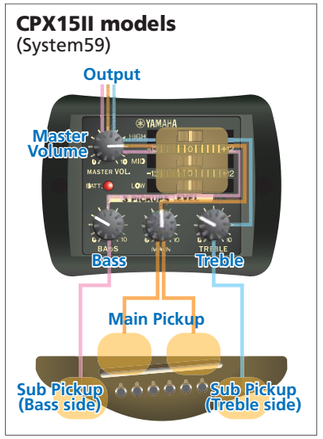
In the one-way System 56, the signals from two A.R.T. pickups located under the ends of the saddle are combined to produce well balanced output.

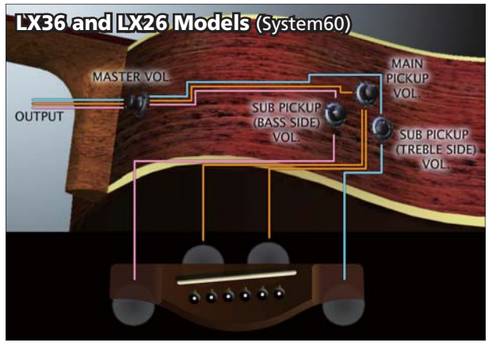
The three way System 57, System 59 and System 60 configurations actually employ a total of four pickups strategically located for outstanding sound and tonal flexibility. In addition to two pickups placed under the ends of the saddle, two more pickups are located near the bass and treble ends of the bridge base. The output of the main (saddle), bass, and treble pickups can be blended as required to achieve the ideal balance. System 57 and System 59 additionally include a three band equalizer for fine tonal adjustment. Rather than a preamplifier panel fitted into the upper side of the guitar, System 60 features pop up knobs that provide easy control access while staying out of the way when not being used, without compromising the visual elegance of the instrument's exquisite side wood. NX series guitars feature System 61, newly designed to complement the characteristic warmth and full mid-range tone of these nylon string acoustic instruments.



Individual volume controls for the treble and bass side pickups make it easy to deliver ideally balanced, natural sound with robust lows and clear highs.







Current three-way systems using a total of four individual A.R.T. pickups each: System 57, System 59, and System 60.

First-class Studio Sound, Without the Studio

Yamaha's groundbreaking SRT (Studio Response Technology) system employs advanced digital processing to accurately recreate the sound of the guitar as recorded in a world-class studio by a highly skilled engineer using the best microphones available. The data used for SRT processing has actually been recorded in some of the best studios in the world specifically for the guitar model in which it is to be applied. The player has fingertip control of microphone selection, positioning, and other parameters, making it easy to achieve optimum tone for a variety of live and recording applications.

Three High-End Mic Types

Select from models of three microphones most-favored by recording engineers around the world. (Mic models are created using data collected from these microphones.)

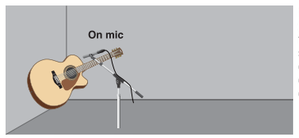
Type 1: Neumann U67
Vintage condenser microphone known for its wide frequency range and dynamic response. Good for all musical playing styles, follows phrasing well. Recommended for comping and rock playing.

Type 2: Neumann KM56
Vintage condenser microphone known for smooth, accurate and delicate high-end. Recommended for arpeggios, ballads, finger picking, etc.

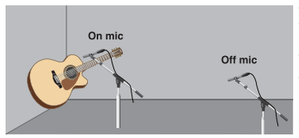
Type 3: Royer R-122
Modern ribbon microphone known for its soft response with a gentle high-end and thick and warm tone. Smooths hard picking into a rounder tone. Recommended for Jazz and Blues playing.

Professional Mic Positions

Choose miking positions close or far.



FOCUS: On mic setting (mic positioned 20-30cm from the guitar). Captures string and body resonance clearly to deliver a fat, expansive sound and excellent projection.



WIDE: On Mic combined with Off Mic setting (mic positioned a few meters away from the guitar). Close to the ambient sound that the ear hears when listening to a guitar. Recommended for solo and ensemble playing.

Adjustable Body Resonance

The RESONANCE knob allows you to add body resonance to the sound, emphasising the natural tone of the guitar.

* The RESONANCE control is only effective on the mic sound.

★ Keep Feedback Under Control
These instruments incorporate Yamaha's original A. F. R. (Auto Feedback Reduction), which automatically delects the frequency causing the feedback and applies a notch filter to suppress the problem frequency. When feedback occurs, simply switch the A. F. R. button ON. Up to five filters can be applied.

Blending Piezo and Mic Sound Sources

Blend piezo pickup and microphone sources to create a wide palette of tonal variations. Blending the sound from the piezo pickup with the sound from the built-in mic adds sharpness.

(full left) Piezo pickup only

(full right) Mic sound only

Electric Guitar Pickups and Electronics

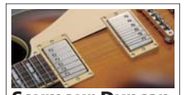
Whereas acoustic guitar pickup systems are usually designed to deliver the acoustic tone of the guitar as naturally as possible, electric guitar and bass pickups are part and parcel of the instrument's sound. In fact, they are just as important and influential as the woods used in an acoustic guitar. But the choice is by no means simple. The design and materials of the guitar, the player's touch, the type of music being played, and the amplification system and processing gear being used are just some of the factors that play a significant role in determining the final tone produced by the pickups. It is both complex and subjective, and only the artist is qualified to judge. It is Yamaha's role to provide a range of choices that satisfy the widest possible range of player requirements.

Matching the Pickups to the Instrument

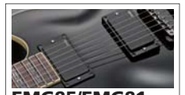
Although the quality and performance of the pickups themselves are vitally important, equally critical to achieving optimum tone is how well the pickups are matched to the instrument. Why is this so? Electric guitar and bass pickups become an integral part of the instrument's sound producing system. Although it seems that the pickups are simply picking up the vibrations of the strings and generating corresponding electrical output, the true situation is actually a little more complex. The body of the instrument resonates in response to string vibration, and since the pickups are attached to the body they are a part of that resonant system. A certain amount of inter-modulation between string vibration and resonance transmitted to the pickups via the body is inevitable, resulting in tone that is unique to that specific combination of pickup and instrument. The possible variations are innumerable, and a great deal of time and effort goes into developing or finding the pickup(s) that will give the most musical voice to any given instrument.

Taking Advantage of the World's Pickup Resources

Yamaha develops and builds many pickups in-house, often in cooperation with renowned artists whose sound and approach to playing have become standards to which upcoming artists aspire. The pickups on the BB2000/1000 basses are eminent examples. But there's no denying that some of the world's leading dedicated pickup manufacturers produce pickups that deliver outstanding tone and response that are precisely what many players want, and there's no reason not to take advantage of such high-quality resources. That's why Yamaha's SG1800 series electric guitars come fitted with pickups from some of the brightest stars in the business: Seymour Duncan and EMG. Yamaha worked closely with these manufacturers to find pickups that bring out the very best in these fine instruments, and the results speak for themselves.



Seymour Duncan '59 Pickups
(SG1820)



EMG85/EMG81 Pickups
(SG1820A)

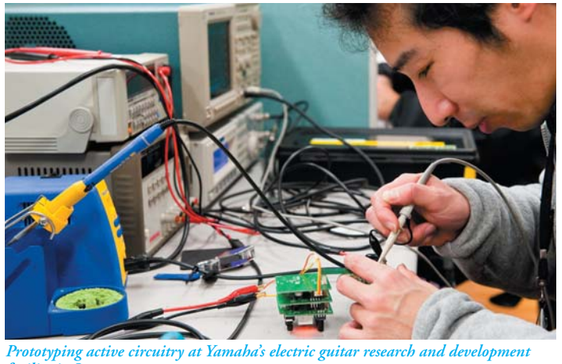
Seymour Duncan SP90 Pickups
(SG1802)

Active or Passive

Like virtually all other pickup related choices, the choice of active or passive pickups is a highly subjective one. Both types have advantages, and it is up to the artist to decide which is best for his or her style. Yamaha's current lineup of electric guitars and basses includes instruments with both types of pickups. Here's a quick rundown of their main characteristics.

Passive	Passive pickups have no onboard electronics and don't require battery power. They tend to bring out more of the instrument's wood tone, and many feel that for this reason they have more "character." The response and tone of passive pickups can be affected to some degree by the type and length of the cable used to connect the guitar to effect units or amplifiers, and by the input characteristics of the effect unit or amplifier used.
Active	Active pickups have onboard amplification that requires a power source, usually a battery housed in the instrument's body. They tend to have smooth, even response, and onboard tone control electronics often allow a wide range of tonal variation right from the instrument's controls. Active pickups are relatively unaffected by cables and the input characteristics of subsequent devices. Examples of active pickups include the EMG81 and EMG85 pickups used on the SG1820A guitars, and the original Yamaha active pickups used on the TRB series basses.

Of course when it comes to developing active pickup systems the circuitry must be designed and built with the same care and attention to detail that goes into every other aspect of the instruments themselves.



Prototyping active circuitry at Yamaha's electric guitar research and development facility in Japan.

The Tone is in the Details

Literally everything about a guitar or bass pickup affects the way it sounds, right down to the type and placement of screws used to hold parts together. The materials used for bobbins and base plates are significant, and there are almost infinite variations in how the coils can be wound: type of wire, tighter, looser, even, scattered … and more. And, as implied above, the only way to know how a given pickup will sound in a given instrument is to install it and play it. The number of variations is astronomical, but Yamaha provides a comprehensive range of choices that provide solid foundations for a wide range of tonal preferences.

This programmable pickup winder at Yamaha's research facility is used to test different combinations of coil winding parameters.

Even the controls, capacitors, and type of wire used to connect everything together can affect the final sound, so a great deal of R&D goes into selecting those components as well.

Installing the wiring and controls in a BB-series bass.

Craftsmanship

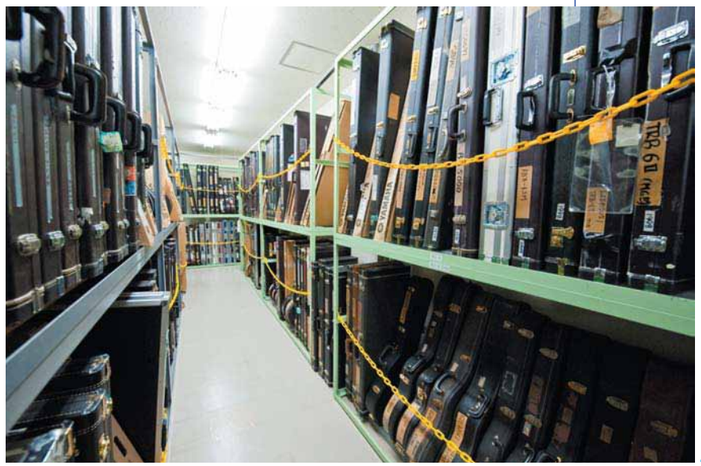
Even with the advanced manufacturing technology available today it simply isn't possible to entirely automate the production of first-class guitars. The complexity of the task in addition to the need for constant awareness of the materials being used and the ability to minutely adjust for variations is beyond the scope of available technology.

Machines do play a vital role, but there is no substitute for the skill and sensitivity of experienced craftsmen at many stages during the production of fine musical instruments.

Turning Designs into Great Guitars

Turning designs into great instruments isn't easy. Technical drawings can't convey the intended tone of an instrument, or even much of the construction methodology that creates the desired characteristics and sound. A huge part of the process of creating great guitars comes down experience, craftsmanship, and extensive trial and error testing that builds more experience.

Before the building can even begin the plans and intentions of the designers have to be effectively communicated to the chief craftsmen at the factory who will then develop an appropriate production process. The process will be a combination of operations used for current models as well as new methods and tools devised for use with that specific instrument. Every guitar is different, and coming up with the ideal production methodology and workflow is a critical step in achieving consistently high quality.



Yamaha keeps an extensive archive of past models and prototypes for reference.

Overdoing It

Sometimes "overdoing" things is the only way to ensure that the desired quality is achieved consistently and in every possible situation. Yamaha does take manufacturing details to extremes in many cases, but the final results are unquestionably worth the extra effort.

The Yamaha process of pre-matching acoustic guitar bodies and necks before finishing is one example. Experience has shown that the quality of the neck-body joint plays an important role in maximizing the instrument's tone and response. In short: the fit must be perfect with intimate contact between neck and body. The combination of pre-matching and Yamaha's unique joint configuration ensures that the ideal is realized in every instrument produced.

After finishing the same neck and body are reunited for the perfect neckbody joint.

Body and neck are precisely matched before the finish is applied.

Critical matching between neck and body is just as important for achieving optimum tone and response in electric guitars and basses as it is for acoustic guitars. This process is so sensitive that it can only be done by hand, even for bolt-on necks.

Fine tuning the neck recess in a BB-series bass body.

Another example worth noting is Yamaha's approach to achieving the ideal top curvature for each instrument. A specially designed and built contouring sander is used to shape the edges of the sides such that the top is given an outward curve that places the point at which the bridge will be attached at a precisely defined height above the edges. This helps to optimize transmission of string vibration as well as producing a strong, durable top.

This type of attention to detail extends throughout every phase of the guitar production process, from raw materials and design through final testing.

A craftsman loads a body assembly into the contouring sander.

An Ideal Blend of Machine Precision and Human Skill

There are, of course, some tasks that are best left to machines – particularly those that require extreme precision and repeatability. Cutting the fret slots in fingerboards is a critical job that is handled by precision computer-controlled machinery, as is basic shaping of solid bodies and necks, for example. But in order to deliver instruments that precisely meet our customer's needs there is often a need for variations that require individual attention. That's where the skill and experience of Yamaha craftsmen can really shine.

Refining body contour on a purpose-built belt sander.

Final smoothing is best done by hand.

Solid electric guitar and bass bodies are initially cut and shaped on computer controlled milling machines.

Basic neck shaping is done by machine, but final shaping is handled by skilled craftsmen.

The Finishing Touches

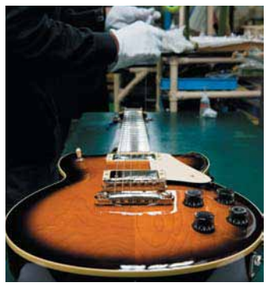
Yamaha spares no effort in ensuring that every guitar and bass leaves the factory in optimum playing condition. Critical players may need to make minor string height adjustments to match their individual playing style, for example, but important details such as fret leveling and finishing are taken to custom-shop level right at the factory.

Properly leveled frets are essential for optimum playability.

No detail of fret finishing is overlooked: here the fret edges are being rounded for playing comfort.

Final assembly is another production step that requires the utmost care if optimum tone and performance are to be achieved. Parts that are not properly aligned or not solidly attached can degrade both sound and playability. Workstations are designed and set up specifically for the assembly tasks to be performed so that the process is as smooth and efficient as possible, allowing the craftsmen to concentrate fully on achieving perfect results.

Installing the bridge pickup on a BB-series bass.


Almost done: stringing an SG.

Crafting the Tools

There is innovation and craft behind the craftsmanship as well. Most of the tools and jigs used for making guitars have to be made by hand for the purpose, and many are created specifically for a single model and won't be used for anything else. Inventing tools and jigs that make it easy for the factory staff to consistently produce perfect shapes and assemblies is an important element of Yamaha's approach to craftsmanship. But tools and jigs can wear and go out of alignment with use, so special care is taken to keep them maintained and in perfect working condition at all times: a vital part of overall quality control.

Special tools assist in precise positioning of critical parts and ensure consistent assembly quality.

A machine designed specifically for drilling solid guitar bodies with repeatable precision.

This machine's sole purpose is to precisely contour electric guitar fingerboards before the frets are installed.

A variety of body jigs at the factory.

Keeping the Craft Alive

Because of the heavy reliance on skilled craftsmanship in the making of fine guitars, the only way to ensure consistent, continued quality into the future is to pass the know-how on to young craftsmen. Yamaha makes this process an "official" part of the guitar manufacturing process. This kind of skill can only be fully passed on person to person through involved hands-on apprenticeship. Craftsmen come and go, but Yamaha is dedicated to ensuring that the basic skills as well as the many innovations developed along the way are effectively passed on so that Yamaha guitars can continue to evolve.

Like most other production steps, spray finishing is an art that takes time to learn.

It may look easy, but guitar binding is extremely difficult to apply properly and consistently.

Quality Control from Concept to Service

Yamaha takes the concept of "quality control" way beyond simply checking finished products for defects. In fact, Yamaha maintains dedicated staff and certified worldclass facilities that are devoted solely to quality control, ensuring that all products are designed, developed, manufactured, shipped, and serviced with maximum quality maintained throughout the entire process.

Quality control is just as important for guitars as it is for Yamaha's industry-leading digital mixing consoles, for example, but the way it is applied differs in some ways in accordance with the way guitars are crafted as opposed to purely electronic devices.
The most important similarity – a motif that runs through all Yamaha products – is that quality control begins at initial conception and design and carries on right through to customer service after the product has been sold.

Creating Quality that Lasts

The Yamaha quality control process can be broadly divided into 6 phases that begin at a guitar's conception and continue for long after it is sold and in the player's hands.

1: Virtual Review – Creating Quality on Paper

The Yamaha approach is to build quality into every guitar right from the beginning. This means that a proposed design will be subjected to multiple "virtual review" sessions while the instrument is just an idea on paper. Virtual reviews are attended by designers, engineers, craftsmen, players, sales staff … anyone with experience or understanding that can be applied to improve the design and eliminate potential problems before they occur. Designers and engineers from other divisions often join in to help uncover issues from a fresh perspective: drum or violin developers, for example, sometimes make invaluable contributions. Every aspect of the proposed guitar is thoroughly reviewed, as are the tools and methods by which it will be constructed. Only when everyone involved is satisfied that the design meets Yamaha's standards as well as those of the end user can development proceed to the next step.

Naturally, players are consulted at every stage of the development process, as appropriate to the product. For example, performing professionals might be enlisted to review a pro-class instrument, while guitar teachers might be consulted for student models. The players evaluate the guitars from a "musical instrument" perspective rather than a "products" perspective. And that, in the final analysis, is what it's really all about.

2: Initial Prototype – Ideas Become Reality

Phase two of the development process is the construction of the first prototype. The first prototype will be built according to the specifications that come out of the initial virtual reviews, and will be once again subjected to multiple reviews at which problems will be identified and measures for their resolution decided upon. New features, in particular, will be examined in detail to determine whether they actually fulfill a need and whether there's any way they might be improved. In general, the first prototype is used to physically review the design and features of the product itself.

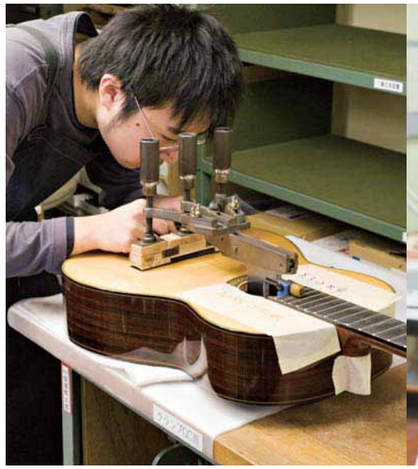
3: Pre-production Prototype – Refining the Process

Once the first prototype gets the green light from the review teams, a second "preproduction" prototype is made. The second prototype is used both to check for problems that may have been overlooked in the first prototype, and to refine the production process by which the instrument will be made. Every design requires its own special manufacturing techniques in some areas, and it is essential to ensure that the entire manufacturing process will run smoothly and deliver consistent results.
Every tool, jig, and process that will be used to build the final product will be reviewed in detail.

Guitar construction depends heavily on custom-made tools and jigs, and these must be designed and built with as much care as the guitars themselves.

4: Production – Non-stop Quality Control

One major difference between guitar manufacture and other types of production is the involvement of craftsman at every step along the way. On a television production line, for example, there might be tests at specified points during the assembly process, but quality is only monitored at those specific points. In the case of guitar manufacture, on the other hand, the craftsman who is drilling a hole, gluing bracing, shaping a neck, or applying a finish is monitoring the quality of the result as he works. Quality monitoring is a continuous, uninterrupted process. Construction and crafting cannot be separated from quality control, and each individual craftsman monitors his own work as well as those of others working around him with great care and pride.



Guitar craftsmen perform some of the most important quality control functions during production.

Neck contour and dimensions are carefully checked for precision and consistency.

5: Spot Checks and Feedback from the Field – Continued Vigilance

Spot checks are regularly performed prior to shipping products from the factory as well as on products received from off-site factories. If a problem is found on an instrument in production, shipment is stopped immediately and the cause is tracked down and rectified before shipment can resume. Any problems reported by customers are also examined and dealt with immediately.

In addition to spot checks at the factory and general feedback from the field, and functioning independently from the product divisions, is Yamaha's overall quality control department. This dedicated quality monitoring organization will actually buy products from retail outlets and perform random, independent testing. Any issues uncovered are fed back to the respective product departments with orders that the problem be solved posthaste. This type of checking is done from the customer's perspective, totally independent from the development and production divisions.

6: In the Player's Hands – Lasting Quality

Guitar manufacture is not only a matter of selling guitars now, but also of considering how those guitars will perform decades after being made. In addition to a worldwide service network dedicated to responding to customer's needs as swiftly and as appropriately as possible, Yamaha maintains stocks of parts that might be needed to repair and service guitars for as long as eight or ten years after the product has been discontinued. Sometimes longer. The cost is enormous, but the results in terms of overall "quality" are well worth it.

Severe Quality Testing

Since quality cannot be fully assured on the basis of theory alone, it becomes necessary to subject actual instruments and parts to "controlled abuse" that tests their actual performance, stability, and reliability to extremes.

Yamaha maintains a number of facilities dedicated to physical testing and quality control – including the world-class Yamaha Quality Support Center that houses some of the most advanced and sensitive testing facilities for electronic devices available anywhere, plus some tortuous durability tests that are almost shocking in their severity.

Guitar truss rods being tested under tons of pressure at Yamaha's certified Quality Support Center.

Accelerated Environmental Testing

Of paramount importance in manufacturing guitars for worldwide distribution is the need to ensure that the instruments will be able to withstand a tortuous range of environmental conditions without damage or compromised playability. A neck that warps with every change in humidity will be nothing but frustration for the player. At the extremes wood can crack and glue joints can separate … none of which is acceptable for Yamaha guitars.

Some of the temperature and humidity testing chambers used for accelerated environmental testing of guitars.

Acoustic guitar electronics undergo rigorous electromagnetic testing at Yamaha's world-standard EMC testing facilities.

To ensure that Yamaha guitars remain stable and reliable through all types of environmental conditions, year after year, samples are subjected to accelerated testing that simulates the severest conditions imaginable. The test samples will be kept at -20 degrees Celsius for a period of time and then moved to a +50 degree environment, and that process will be repeated several times while measurements are made to check integrity and dimensional stability. The same applies to extremes of atmospheric moisture, with instruments being subjected to alternating periods at 90% and then 20% humidity. This type of testing requires large-scale specialized facilities that are beyond the scope of most manufacturers.

Some guitars chill at a frosty -20 °C.

Test guitars are careful measured for warpage and distortion as they are moved from one extreme environment to another.

Vibration and Drop Testing

Instruments must reach the customer in perfect condition, so packaging and shock resistance are important quality issues. Testing is brutally simple: drop the product from a specified height (onto corners as well as top, bottom, and sides), and subject it to severe mechanical vibration covering a range of frequencies for extended periods.
If the product and packaging can survive Yamaha's internal testing, they can survive transportation around the globe under the roughest conditions.

Ouch … a drop test.

Vibration table testing simulates the type of vibration products are likely to encounter during transportation.

The Ultimate Goal

The ultimate goal of Yamaha quality control is total customer satisfaction. That not only means delivering guitars that are stable and reliable, but also instruments that fulfill the player's musical needs and are capable of growing and improving along with the player. And when a problem occurs, responsive and effective support becomes an essential element of the quality equation as well. Easier said than done.
Like the products themselves, quality management must continually evolve to keep pace with continuously changing markets, user needs, and technology. Yamaha is right at the leading edge.

Worldwide Standards

Yamaha guitars are manufactured at three main locations around the world: the Music Craft factory and Custom Shop in Japan, the Hangzhou Yamaha factory in China, and Yamaha Music Manufacturing Indonesia.
From acquisition and selection of raw materials through production processes, Yamaha maintains the same demanding standards at all factories to ensure that every instrument that bears the Yamaha logo delivers the superior fit and finish plus the outstanding sound and playability that our customers have come to expect.

Room to Grow

Although the foundation for Yamaha guitar craftsmanship was originally established in Hamamatsu, Japan, with assistance from distinguished Spanish guitar builders Eduardo Ferrer and Manual Hernandez, once the craft was mastered it was possible to move some production overseas in order to satisfy the growing need for high-quality instruments at all price points. That basic sequence continues to be repeated for each new model: initial development and manufacturing processes design take place at the Music Craft factory in Japan, then production is assigned to one of the overseas factories. The Music Craft factory is pivotal in achieving and maintaining Yamaha quality throughout the world.

Hangzhou Yamaha, China.

Yamaha Music Manufacturing Indonesia

People and Communication

Quality is all about people, and Yamaha is proud and honored to be working with some of the finest at our factories, research facilities, and offices around the globe. We've spared no effort in developing open lines of communication that effectively remove obstacles posed by physical distance and cultural differences so that overseas production is tightly integrated with Japan's. Feedback is immediate so that any necessary modifications or upgrades can be implemented to ensure that Yamaha's stringent quality standards are upheld in every instrument at all times.

From the Player's Perspective

Yamaha's goal is to create guitars that ideally meet the real-world needs of professional and amateur musicians who depend on their instruments for their livelihood, art, and enjoyment. Acquiring feedback directly from and cooperating with players in the development of designs and features is the most meaningful, effective way to refine the instruments we produce. With that understanding, Yamaha places great emphasis on communicating with players and providing opportunities for them to evaluate instruments and suggest improvements.

YASH: Yamaha Artist Services Hollywood

One facility set up specifically for artist involvement and cooperation is YASH: Yamaha Artist Services Hollywood. YASH is located at the heart of the LA music scene, sharing the area with numerous recording studios and venues as well as top-level artists in a wide range of musical genres.

The operation began as YGD (Yamaha Guitar Development) in 1989, and was expanded in 2006 to become YASH, with display and evaluation rooms, recording facilities, wood and metal shops, an electronics lab, and a photo studio.
Of course not all evaluation occurs at the YASH facility itself. The location of YASH provides easy access to a number of important music centers throughout North and South America, allowing us to stay in touch with artists wherever they may be and stay abreast of developments that can be implemented in our development and production.

The guitar evaluation room at YASH.

ART: Artist Related Twenty-one, Tokyo

Another important center for artist relations is the ART (Artist Related Twenty-one) in Tokyo, Japan. It is a place where Yamaha designers and builders who are involved with day-to-day production at Yamaha's main custom shop and factories can directly communicate and exchange ideas with artists who are either touring in Japan or have come specifically to work on Yamaha instrument development projects.

Most artists are keenly aware of their own needs as well as those of other musicians around them, and are usually happy to evaluate prototypes and share ideas and opinions on how instruments can be improved whenever the opportunity arises. Thus the quality of Yamaha guitars is not only dependent on the designers, craftsmen, and support staff at Yamaha's guitar divisions and factories, but also to a large degree on the players who use them.

Nathan East evaluates a Yamaha bass guitar.

Mike Stern discusses a selection of new guitars.

Classical Tradition

Classical guitars evolved from relatively simple four-string instruments in the 1400's to the highly refined six-string concert instruments we know today in a steady, organic progression that is inextricably intertwined with the evolution of guitar music. The basic form of the "modern" classical guitar was developed by Spanish luthier Antonio de Torres in 1883, and it is his work that continues to influence and guide the hands of the world's top craftsmen today.
Yamaha is proud and honored to have been able to take part in that evolution, through guidance received directly from eminent luthiers from the Torres line, as well as cooperation with some of the most distinguished artists in the genre.

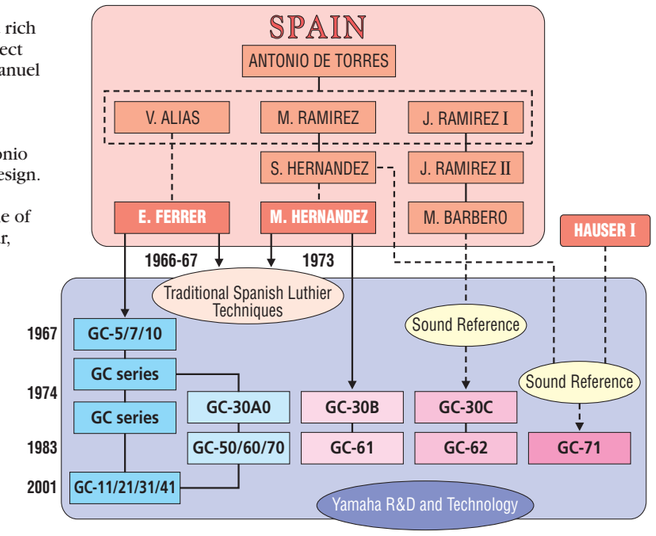
Yamaha's top-line Grand Concert Custom guitars. From left to right: GC70, GC70C (cedar top model), and GC71.

A Noble Lineage

Classical guitars and classical guitar music are firmly rooted in a rich tradition that is the foundation for the entire genre. Through direct tutelage from renowned Spanish luthiers Eduardo Ferrer and Manuel Hernandez, as well as sonic reference to legendary instruments created by other masters such as Santos Hernandez, Marcelo Barbero, and German luthier Hermann Hauser, Yamaha classical guitars are descendents of a proud lineage that began with Antonio de Torres (1817 ~ 1892), the father of modern classical guitar design. No effort is spared in upholding and refining the demanding standards of tone and quality passed down to Yamaha from some of the most eminent luminaries in the history of the classical guitar, and we carry on the tradition with both humility and pride.

Technical skill and know-how received directly from masters in the field is of inestimable value, but so is thorough familiarity with the sound and music the instruments are designed to create. Yamaha maintains an extensive and enviable collection of guitars created by the most esteemed craftsmen the world has ever known. To this day the response and sound of the instruments in this one-of-a-kind collection are diligently internalized by Yamaha classical guitar designers and craftsmen, and thus become their own reference standards. Those standards are very high indeed.

Yamaha Custom Guitar Lineage



* Some models in this chart may not be available in all areas due to export restrictions.

Andrés Segovia

(February 21, 1893 ~ June 2, 1987)

Regarded as one of the most important masters in the history of the classical guitar, Andrés Segovia played a significant role in Yamaha's emergence as a world-class classical guitar manufacturer.

Wishing to create top-quality classical guitars of original design that would satisfy the most discriminating artist, Yamaha paid a visit to the Maestro and asked his advice. Segovia had been impressed by the quality of Yamaha pianos, and was confident that Yamaha could produce outstanding classical guitars as well. He generously provided invaluable guidance that paved the way for the development of some truly outstanding instruments.

After much trial and error, plus the development and application of original Yamaha techniques, one close copy of an existing instrument and three original Yamaha instruments were taken to Segovia for evaluation. Segovia chose one of the original Yamaha models as being the best. With the approval of the Maestro himself, that guitar became the Yamaha GC70C Grand Concert Custom model, and was added to Segovia's personal collection.

Baden Powell

(August 6, 1937 ~ September 26, 2000)

Brazilian guitarists Baden Powell de Aquino is known for his inspired performances in a wide range of Latin styles. He is also known for his outstanding tone, which for the last ten years of his life was primarily elicited from a Yamaha GC71 Grand Concert Custom guitar.

Powell was introduced to the GC71 when Yamaha designer Akio Naniki personally delivered one to his home. Powell loved the GC71 from the first time he played it, and used it right up until his death in 2000.

The following is an excerpt from a letter Powell wrote to Yamaha in 1985 (translated from the original Portuguese): "This guitar allowed me to lose myself in concert. It charmed other musicians, and moved us all greatly. I can declare that this is no ordinary guitar. It has life!"

People

Any organization is the sum total of the people involved. Talking to the guitar design and production staff at Yamaha reveals a common thread of singular enthusiasm and dedication to creating some of the finest guitars in the world.
These people are enviably happy doing what they do, and take great pride in the results.
This, perhaps more than anything else, is the true foundation of Yamaha quality.

Hiroshi Sakurai

Product Plannning Group

Hiroshi Sakurai leads Yamaha's steel string and non classical nylon string acoustic guitar design and production teams with enthusiasm and passion. Like most of the staff at Yamaha he is a player himself and makes it a point to get together with his band whenever possible in order to stay in touch with the needs of players and the underlying reasons he's making musical instruments.

When asked what was special about Yamaha's approach to designing and building guitars, Mr. Sakurai offered the following thoughts:

"One of our strengths is the control and consistency of our design process. All designs begin with specifications and technical drawings from the design team rather than arising haphazardly or being copied from somewhere. All of our designs are original. Once the initial design has been committed to paper, the physical realization of that design becomes a matter of trial and error, usually involving multiple prototypes. Experience guides the process."

"Designing top quality guitars isn't a straightforward undertaking. For example, a guitar's neck has a large effect on the overall sound, but the neck itself is a complex structure consisting of the neck materials and shape, the headstock, the tuners, the truss rod, the nut, the fingerboard, and even the glue that attaches the fingerboard to the neck. All of these elements contribute to the total effect, and we will not compromise on any of them. And we use our original dovetail joint on all acoustic guitars, from the top to the bottom of the line. The decision to take that comparatively difficult route was made after extensive tests on dovetail and bolt on necks. We came to the conclusion that our dovetail joints produced superior results. There are an astonishing number of details that make up the total sound of the instrument that we have to be aware of and stay in control of at all times. Many of the details aren't visible from the outside. The bridge plate – glued under the bridge area, under the top – is one such example. The material, size, and thickness of the bridge plate affect the basic tone of the guitar in a crucial way, and the parameters have to be carefully refined. Even the angle of the strings from the string pins to the bridge has a significant effect, and this is all part of the guitar's design."

"It's easy to build guitars with a big sound, but such guitars don't usually age well and generally won't have the durability to withstand years of use or changes in environment. Our ideal is to create guitars that will grow with the player, maturing over a period of years to become an integral part of the player's sound and style."

Fumio Naruse

Production Planning Group

Fumio Naruse has been with Yamaha for around 33 years, and currently applies his extensive experience and knowledge to guiding Yamaha classical guitar production. But Mr. Naruse's influence actually extends beyond classical guitars.
He was part of the first L series production team and remains involved to this day. He was also a key member of the team that developed the first Yamaha electro-acoustic guitars.

Mr. Naruse has seen Yamaha guitar production evolve significantly over the years, and offers the following insights:

"In the early years much of Japan's guitar production was based on copying existing designs. Yamaha was more interested in creating original instruments, so master classical guitar builder Eduardo Ferrer was invited from Spain to teach traditional Spanish guitar building technique to the Yamaha craftsmen from the ground up. That was in the late 60's. One of Yamaha's craftsmen then travelled to Spain where he studied for several years with Ferrer and later Manuel Hernandez, another renowned master Spanish luthier. In 1973 Hernandez came to Japan where he worked with the Yamaha custom guitar shop team to refine production techniques. Of course the climate and working environments of Spain and Japan are quite different, so adjustments had to be made – an experience that taught us the importance of creating an optimized working environment for both classical and steel string guitar production."

"Our biggest challenge is to impart as much of the quality we can put into hand made guitars into our factory made guitars as well. A lot of this depends on the tools and jigs we make in order to build the guitars. But even if we have precisely machined jigs that can repeatedly create a specific shape, adjustments still have to be made to the thickness of the wood, for example, to compensate for variations. Two guitars built to precisely the same dimensions can sound completely different due to subtle differences in the materials used. The ability to adjust for those differences is essential to being able to deliver consistent quality."

"But it's the elements that aren't visually apparent that are the most difficult: drying the wood, for example, or how the layers of finish are formed. One of Yamaha's strengths is our ability and dedication to creating our own finishes. These are formulated both to be optimal in acoustic terms – they won't damp the sound of the instrument – and safe for the environment. We apply an extraordinary amount of energy and resources to this, and have been doing so for more than 30 years. The accumulated result is a large part of what we call 'Yamaha quality.'"

"We take great pride in the fact that we don't cut corners. All Yamaha guitars are built without compromise. We don't follow trends or fashions either. We stick to the basic core values of guitar craftsmanship in order to deliver world class tone and playability."

Hiroyasu Abe

Wood Engineering Group

Hiroyasu Abe is a key figure in Yamaha's Wood Engineering Group: the division responsible for basic research on wood processing and optimization technology as well as adhesives and finishes. In a sense all subsequent guitar production hinges on the quality and consistency of the materials developed, tested, and supplied Mr. Abe's team.

"Our division provides a level of involvement that we believe is unique among guitar manufacturers. We develop and thoroughly test adhesives, finishes, and wood processing methods that are then passed onto the factories for actual application in the manufacturing process."

"One of our main concerns at the moment is the development of effective adhesive and finish formulations that don't use VOCs (volatile organic compounds). VOCs are cheap and easy to use, but they're bad for the environment and must be avoided."

"Since our work is essentially basic materials research, it can take years to arrive at successful solutions to some problems. That's where Yamaha's long years of experience in the field really make a difference. We have an extensive database of knowledge on which to draw, and are adding to it all the time. Our A.R.E. (Acoustic Resonance Enhancement) process that is beginning to be applied in guitar tops is a good example. We're just beginning to introduce it in actual products, but we've been developing and testing it for years. There is a lot of work behind A.R.E., but the advantages it provides in terms of tone make the effort more than worthwhile, and the benefits will continue to grow more apparent as time goes on."

Tsugitomo Gotoh

Quality Assurance Section

Effective quality control requires a fine balance between experience and innovation, and it is Tsugitomo Gotoh's mission to ensure that the balance is maintained. Mr. Gotoh discusses his role in the overall guitar production operation with energy and devotion that one soon becomes accustomed to when discussing guitars with Yamaha personnel.

"Yamaha quality control is a long, continuous process that begins with the creation and maintenance of maximum quality from initial design through actual manufacture, and carries on through to the market where our response to feedback from the field after the products have been shipped and sold is just as important. Of course we're concerned with the quality of the product at the point of sale, but we're also very concerned about whether it will still satisfy the customer in, say, 10 years time."

Overall we have a daunting number of details to keep track of. The parameters that define quality for a professional player aren't necessarily the same as those that satisfy the needs of a beginner, and we have to be aware of those differences as well."

"Yamaha has a distinct advantage in that we have in-house facilities for testing that other guitar manufacturers normally don't have access to, and are able to make full use of them in ensuring that our quality standards are maintained at every phase of production and in every model from the most luxurious to the most affordable."

Yasuo Suzuki

Senior Electric Guitar Craftsman
Yamaha Custom Guitar Workshop

Yasuo Suzuki is a key figure behind the production of every Yamaha electric guitar and bass. He is in charge of building the prototypes on which production models are based, as well as special artist models. It's a demanding job that requires more than the ability to build fine guitars. When a drawing is received from the designers, the first task Mr. Suzuki's team must tackle is the creation of jigs and tools that will be needed to craft the instrument so that it faithfully reflects the designers' intent.

"The jigs come first, and we have to figure out how to make them. The designers just provide us with the drawings for the instrument. It's up to us to invent appropriate tools to make the design a reality."

Many of the jigs created by Mr. Suzuki and his team appear to be fairly simple, but it takes years of experience and accumulated know-how to come up with simple, versatile tools that perform precisely and effectively in a variety of situations. It is also essential to match the tools to the facilities in which they will be used, as well as the craftsmen who will use them, so they will consistently produce the desired results in the given conditions.

"We design the entire production process from start to finish. It doesn't matter if the workshop isn't equipped with the right tools, we'll find a way to create what the designers want."

Of course jigs and tools aren't the whole story. Mr. Suzuki knows the woods he uses intimately. How they sound alone and in combinations, and how various cuts respond to stress. Balancing the characteristics of the woods symmetrically in a guitar body is important in achieving optimum sound. Ensuring that the woods don't "move" after the instrument is built is also critical, especially in the neck. As top-quality quality woods become scarce, the final quality of the instruments produced by consummate craftsmen like Mr. Suzuki depends more and more on skill. It all comes down to experience and craftsmanship.

"All of this is what makes my job worthwhile and enjoyable. I've been building electric guitars for about 35 years now, and I still find it satisfying."

Tetsuya Samejima

Senior Craftsman,
Yamaha Music Craft Factory

Already in his 70's, Mr. Samejima is still making guitars and loving it. The twinkle in his eye as he discusses his craft reflects his enthusiasm. Although officially "retired" Mr. Samejima's skill and experience are invaluable to Yamaha, and he continues to oversee production at the Yamaha Music Craft guitar factory in Hamamatsu, Japan, as well as factories overseas, while passing on his extensive knowledge to the younger, upcoming craftsmen.

Mr. Samejima has been making musical instruments for half a century, and guitars for 40 years. He joined Yamaha's guitar production team in the 60's and studied with Eduardo Ferrer while the Spanish master luthier was in Japan working with Yamaha.

Although most of his time is spent on production guitars, one of Mr. Samejima's favorite sidelines is creating totally new "dream guitars" that are not based on existing designs or drawings. While allowing him to flex some creative muscle, it is also a source of new ideas for Yamaha, some of which eventually end up on the production line.

His penchant for new ideas also contributes to guitars that are in production as well. Mr. Samejima is a master at inventing new and more efficient manufacturing techniques, and the many jigs and tools he builds by hand are a staple at the factory. In fact, his talents in this area are so highly valued at Yamaha that he has free rein to optimize production as he sees fit. The result is an extraordinarily efficient process that consistently delivers extraordinary quality.

"Although guitars look simple, they are actually extraordinarily complex, and each and every one is different. They are judged in terms of sound and playability, which are highly subjective and not easily expressed in physical quantities that can be drawn on a diagram. It comes down to experience, and the ability to translate the designer's vision into actual instruments."

His motto: "Never be satisfied with the way things are. There is always a better way. To continually pursue new and better ways of doing things is the driving force behind progress."

Toshihiko Itoh

Senior Craftsman,
Yamaha Custom Guitar Workshop

Yamaha had been mass producing guitars up until 1965, but the establishment of the Yamaha Custom Guitar Workshop in that year marked the beginning of development and production of high quality hand made guitars. Toshihiko Ito joined the workshop in 1967, and was among the craftsmen who studied with master Spanish luthiers Eduardo Ferrer and Manuel Hernandez. Mr. Itoh has been a driving force at the workshop ever since.

In 2007 Mr. Ito received the "Award for Technical Excellence" from Japan's Ministry of Health, Labor and Welfare. This is a yearly award presented to selected craftsmen and technicians who have distinguished themselves through outstanding skill and achievements in their field.

Attracted by the opportunity to build complete instruments from start to finish in accordance with the Spanish tradition, as opposed to working on just one part on a production line, Mr. Ito began studying and building guitars with a passion, often working long after regular working hours to perfect his skills and create the perfect guitar.

"There's no end to learning when it comes to building guitars. Every piece of wood is different, and every guitar must be treated as an individual. That's the fascination for me. It is a very, very deep subject that constantly poses new challenges and surprises."

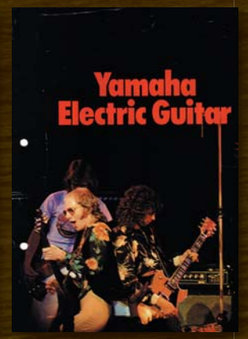
Mr. Itoh is concerned about the increasing difficulty of sourcing top quality woods for use in hand made guitars, but is confident that Yamaha technology as well as the skill and dedication of the younger craftsmen he trains will make it possible to continue to deliver uncompromised sound and playability. But although he is nearing retirement age, Mr. Itoh has no intention of laying down his tools.

"I'll continue building guitars as long as I'm physically capable. This is a job I love, and the more I do it the more interesting it becomes. If I were to be reborn I'd want to be building guitars again. It's that fascinating and rewarding."

History

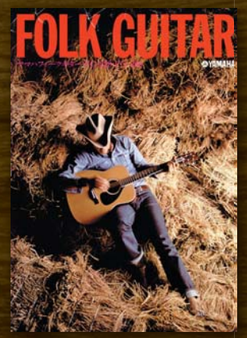
Although full-scale production of Yamaha acoustic and electric guitars officially began in 1966, Yamaha's relationship with guitar craft actually goes back another 20 years. Classical guitar production began in 1946 with the assistance of renowned Spanish luthier Eduardo Ferrer, and the two decades that led up to the launch of mass-produced acoustic and electric instruments in 1966 provided a solid foundation of skill and experience on which the quality and reputation of Yamaha guitars would be based. Yamaha is no newcomer to the field, and is proud to have introduced a number of innovations that have become standards to which others aspire.

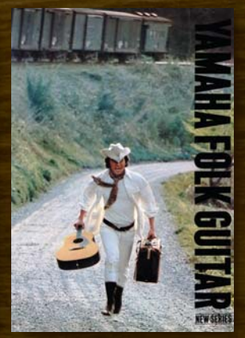
In the end it's all about the sound and the music, and that is Yamaha's primary focus. We do whatever we can to give the artist tools that provide maximum freedom of expression, with consistency and thorough dependability. We are proud to be able to say that our own history is tightly interwoven with the history of modern guitar music.

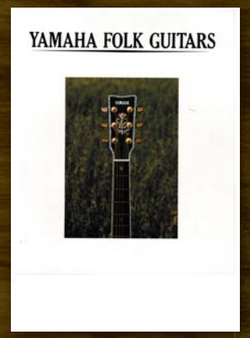


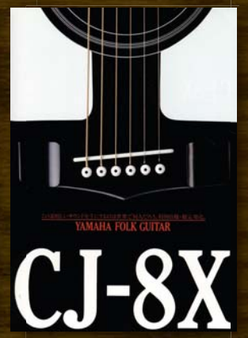
Acoustic Guitars

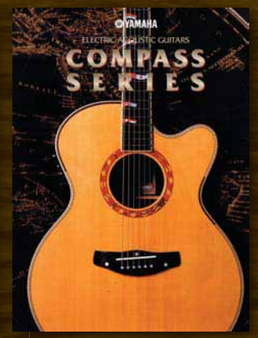
1966	FG180 and FG150. Yamaha's first production "FG" guitars.
1971	FG1500, FG2000 and FG2500 handcrafted series using top-quality solid tone woods.
1972	Overseas acoustic guitar production established.
1974	L31, the first of the high-end "L" series.
1975	Custom-order production started.
1983	CWE series (FN & CN series outside of Japan).
1985	2nd generation L series (LL and LS).
1987	APX series with thin bodies and cutaways.
1994	APX Traveler compact guitar.
1995	FG180 & FG1500 reissued.
1998	CPX "Compass" series with deep bodies and cutaways.
2001	SLG100N Silent Guitar – a revolution in the "acoustic" guitar industry.
2004	3rd generation L series (LL/LS/LJ).
2006	40th anniversary. APX and CPX models updated with A.R.T. pickup systems.
2008	L-series models with A.R.E. processed wood.
2009	NX series electric nylon-string guitars.
2010	SRT pickup system achieves unprecedented amplified realism and tone.

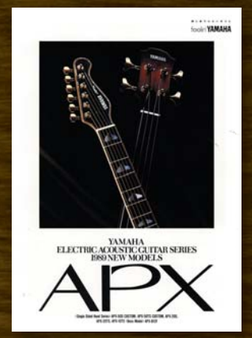


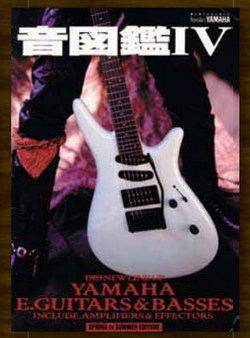


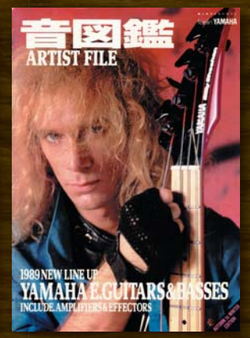


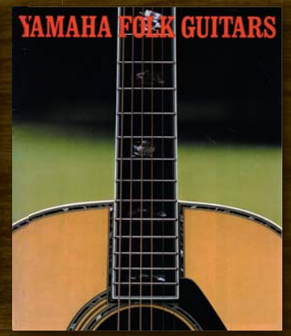


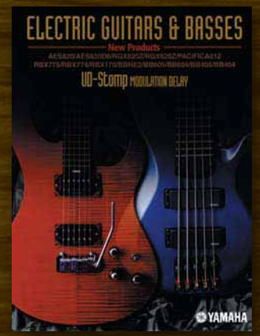


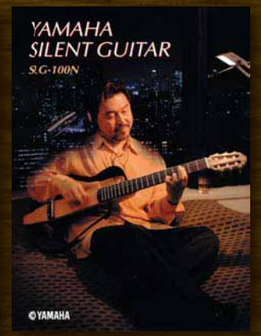












Electric Guitars

1966	SG2 and SG3 with bolt-on necks and single-coil pickups.
1969	Development temporarily suspended.
1972	Development resumed. SG40, SG60 & SG80 with set necks and hum cancelling pickups.
1973	SG30 with symmetrical double cutaways.
1974	High-grade SG175 model adopted by Carlos Santana.
1976	SG2000 and SG1000 developed with assistance from Carlos Santana.
1977	BB1200 bass guitar.
1982	BB3000 bass guitar – Yamaha's enduring relationship with bassist Nathan East begins.
1983	Overseas electric guitar production established.
1987	RGX series launched.
1989	YGD established (Yamaha Guitar Development, later expanded to become Yamaha Artist Services Hollywood).
1990	Pacifica, Attitude, and other models developed by YGD released.
1991	TRB bass series.
1993	Best-selling Pacifica 112 released.
1997	Pacifica 1511MS (Mike Stern signature model), made-in-USA Pacifica USA1 and USA2 introduced.
2000	Drop-6 scale models introduced.
2003	AES620 series solid body guitars with set necks.
2005	RGXA2 and SG series produced at Yamaha Music Craft in Hamamatsu, Japan.
2010	Thoroughly revised SG guitar and BB bass lineup takes Yamaha to the forefront of today's rock sound.